

100

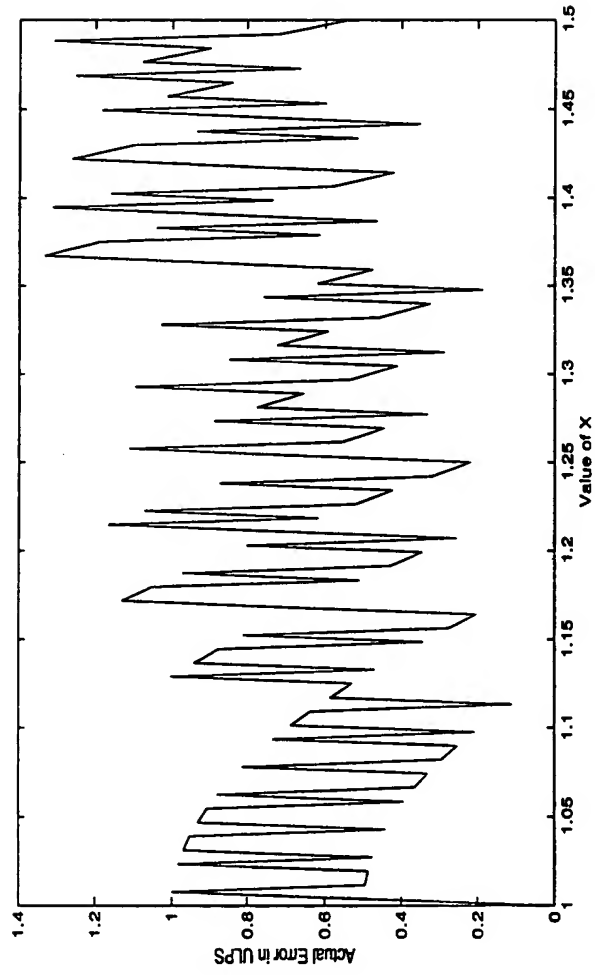


Fig. 1

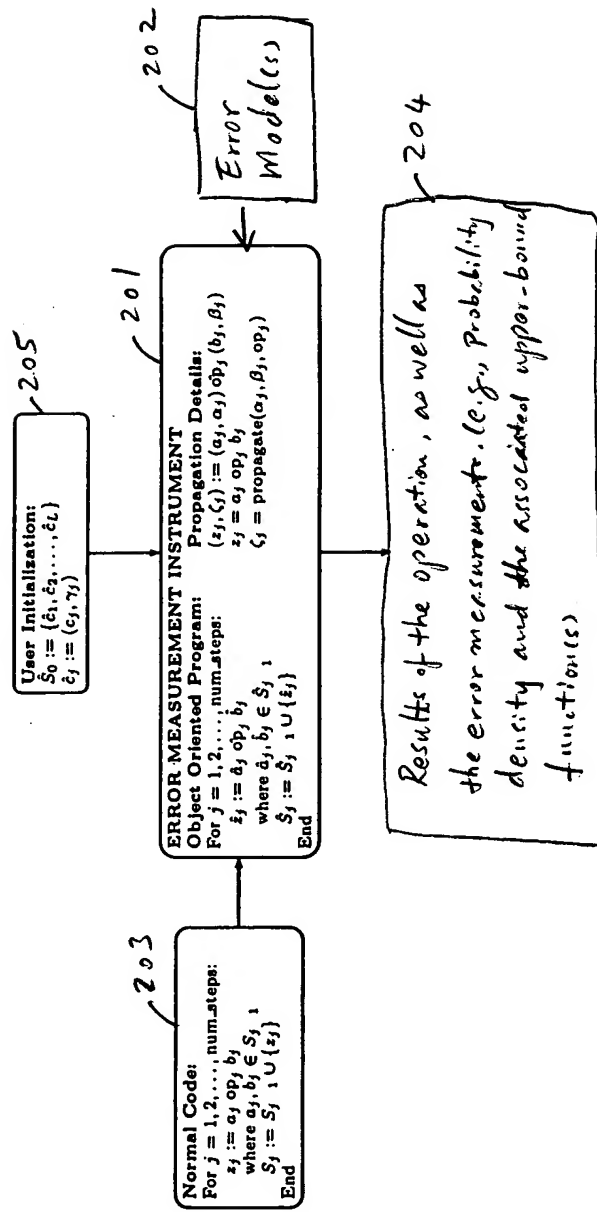
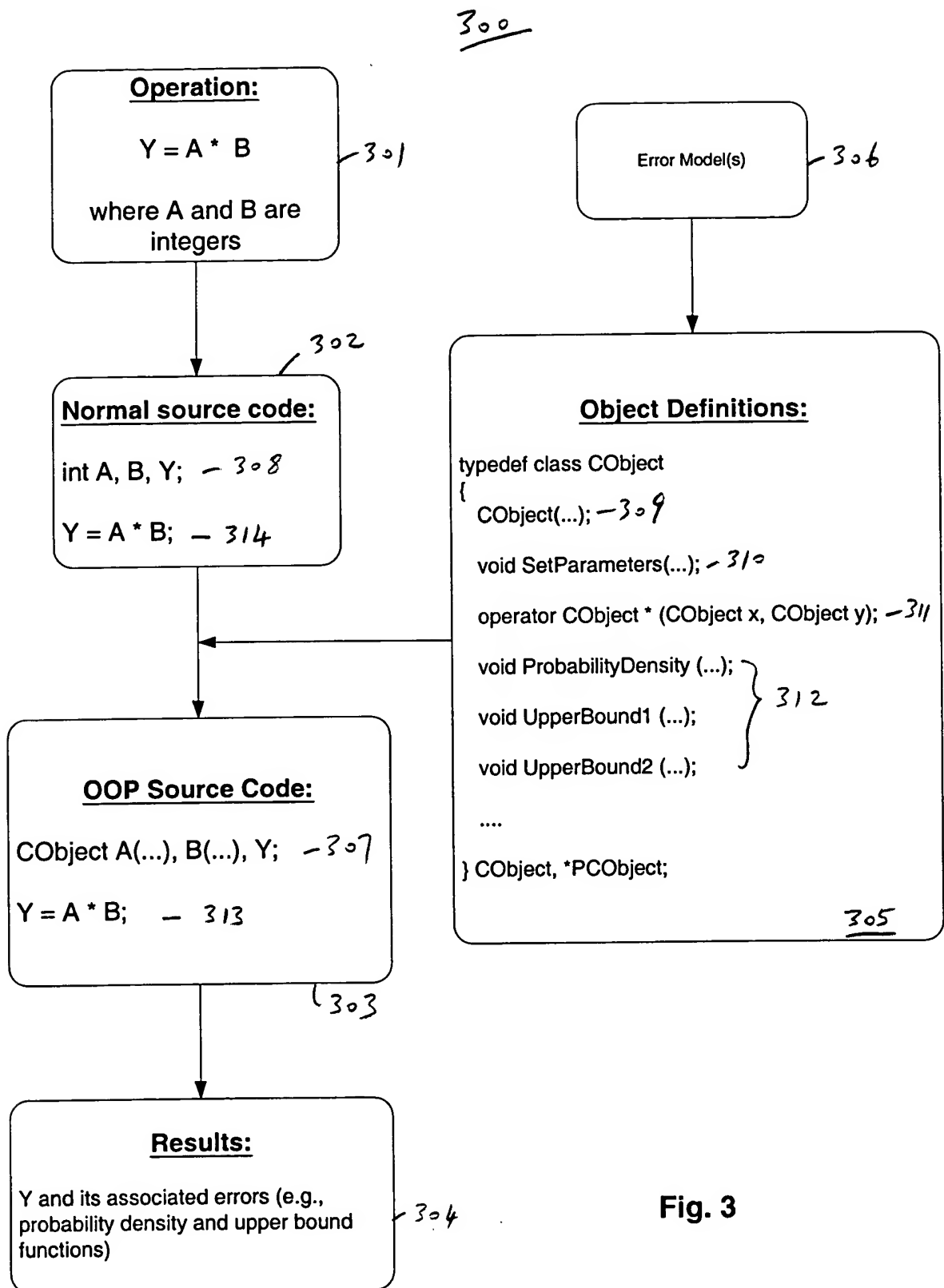
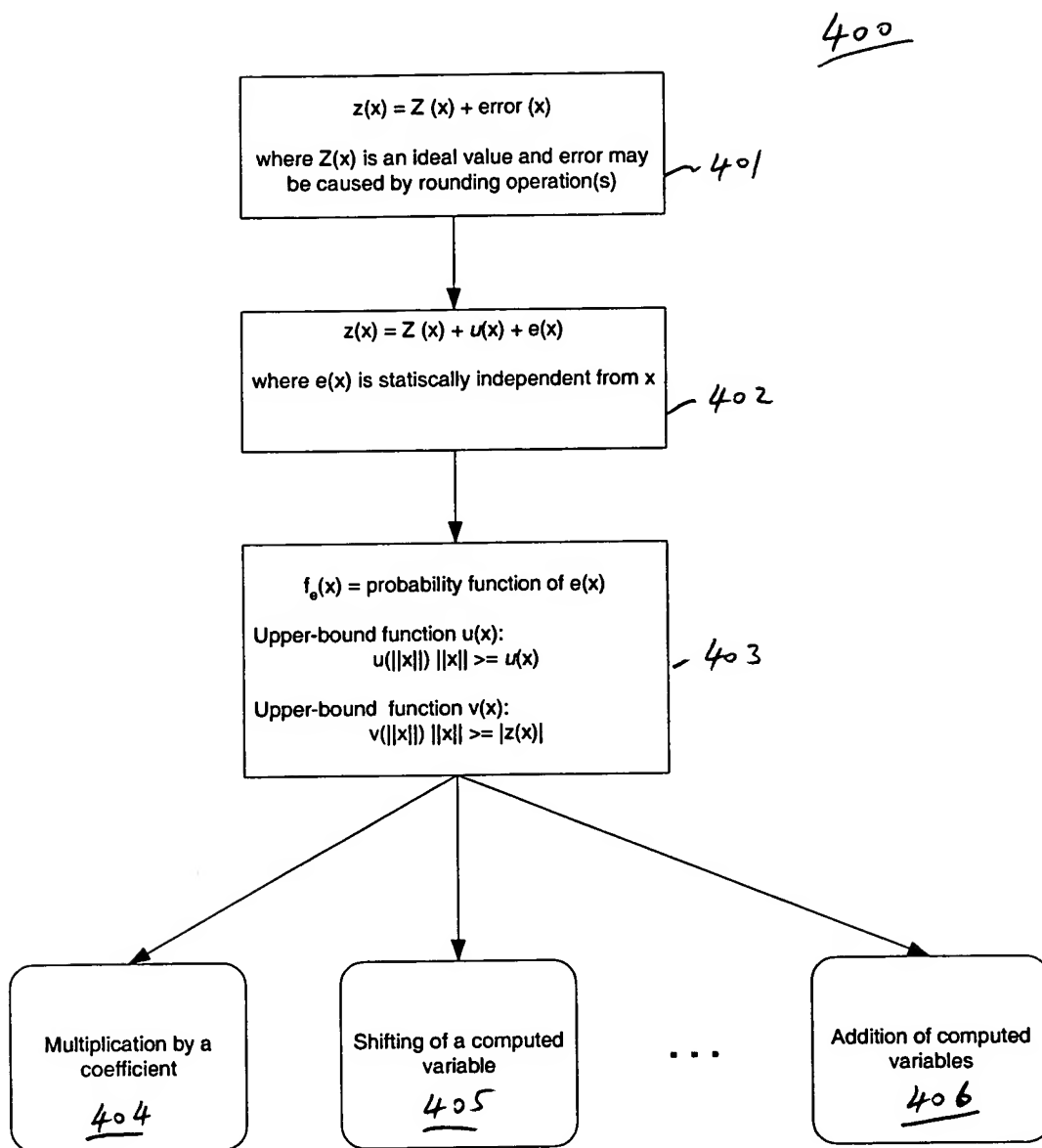


Fig. 2



**Fig. 3**



**Fig. 4A**

404

Multiplication

$$z(x) = \hat{z}(x) + \mu(x) + \epsilon(x) \quad -407$$

$$W = \omega + \alpha$$



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$$Wz(x) = \omega \hat{z}(x) + \omega \mu(x) + \alpha \hat{z}(x) + \alpha \epsilon(x)$$



Error Model:

$$f_e(t) = \frac{1}{W} f_e(Wt) \quad -409$$

$$u(t) = |W| u(t) + |\alpha| v(t)$$

$$v(t) = |W| v(t)$$

Fig. 4B

Shifting of a computed variable

$$g(x) = Z(x) + \mu(x) + G(x)$$

right shifted by  $k$  bits

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$$2^{-k}g(x) = 2^{-k}Z(x) + 2^{-k}\mu(x) + 2^{-k}G(x)$$

411

$$\lfloor 2^{-k}g(x) \rfloor = 2^{-k}Z(x) + 2^{-k}\mu(x) + 2^{-k}G(x) - d(x)$$

where  $0 \leq d(x) < 1$

412

Error Model:

$$f_e(t) = f_e(wt) * \text{uniform distribution } [-1, 0]$$

$$u(t) = 2^{-k} \mu(x)$$

$$v(t) = 2^{-k} v(t)$$

where "\*" is a standard convolution operation

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Fig. 4C

### Addition of Computed Variables

$$g_1(x) = Z_1(x) + \mu_1(x) + \epsilon_1(x)$$

$$g_2(x) = Z_2(x') + \mu_2(x') + \epsilon_2(x')$$

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$$g_1(x) + g_2(x) = Z_1(x) + Z_2(x') + \mu_1(x)$$

$$+ \mu_2(x') + \epsilon_1(x) + \epsilon_2(x')$$

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$$g(y) = Z(y) + \mu(y) + \epsilon(y)$$

$$\text{where } y = x \cup x'$$

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### Error Model:

$$f_{\epsilon}(t) = f_{\epsilon_1}(t) * f_{\epsilon_2}(t)$$

$$u(t)t = \max_{p+q+r=t} \{u_1(p+q)(p+q) + u_2(q+r)(q+r)\}$$

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$$v(t)t = \max_{p+q+r=t} \{v_1(p+q)(p+q) + v_2(q+r)(q+r)\}$$

where  $0 \leq p \leq \max \|a\|$ ,  $0 \leq q \leq \max \|b\|$ , and  
 $0 \leq r \leq \max \|c\|$ ,

where  $x = a \cup b$ ,  $x' = b \cup c$

Fig. 4D

500

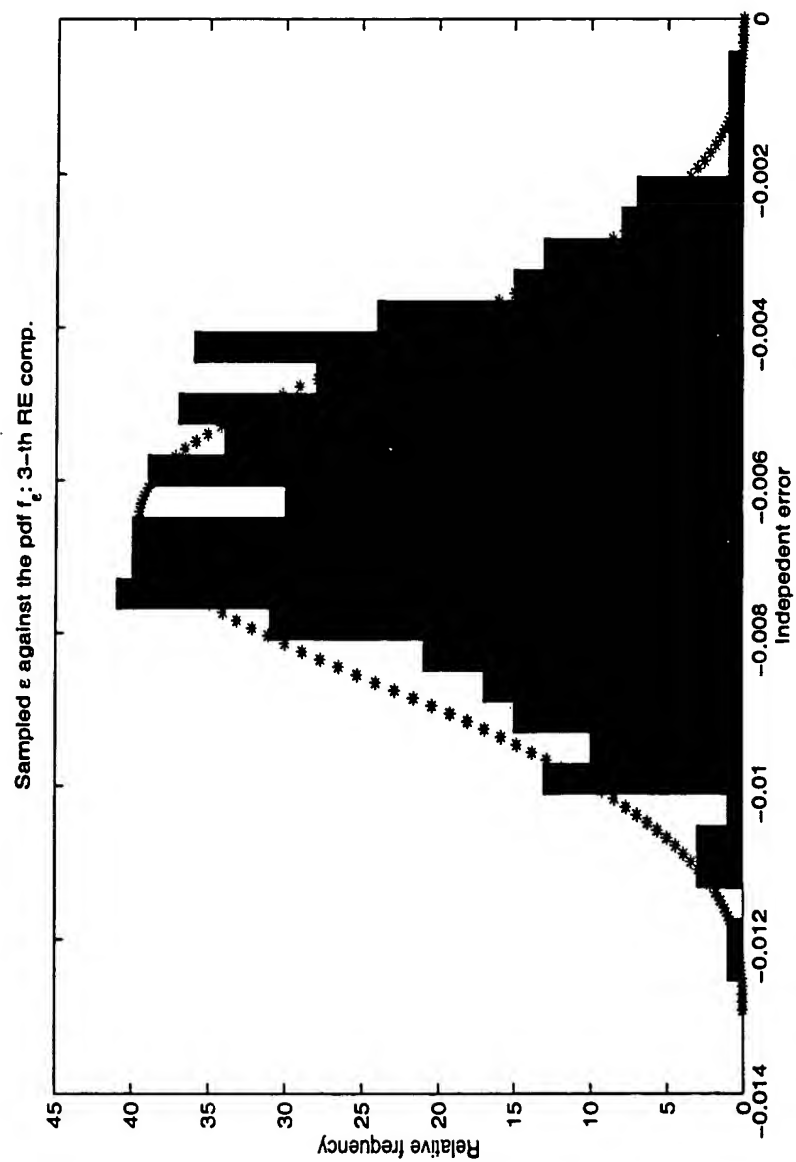


Fig. 5



600

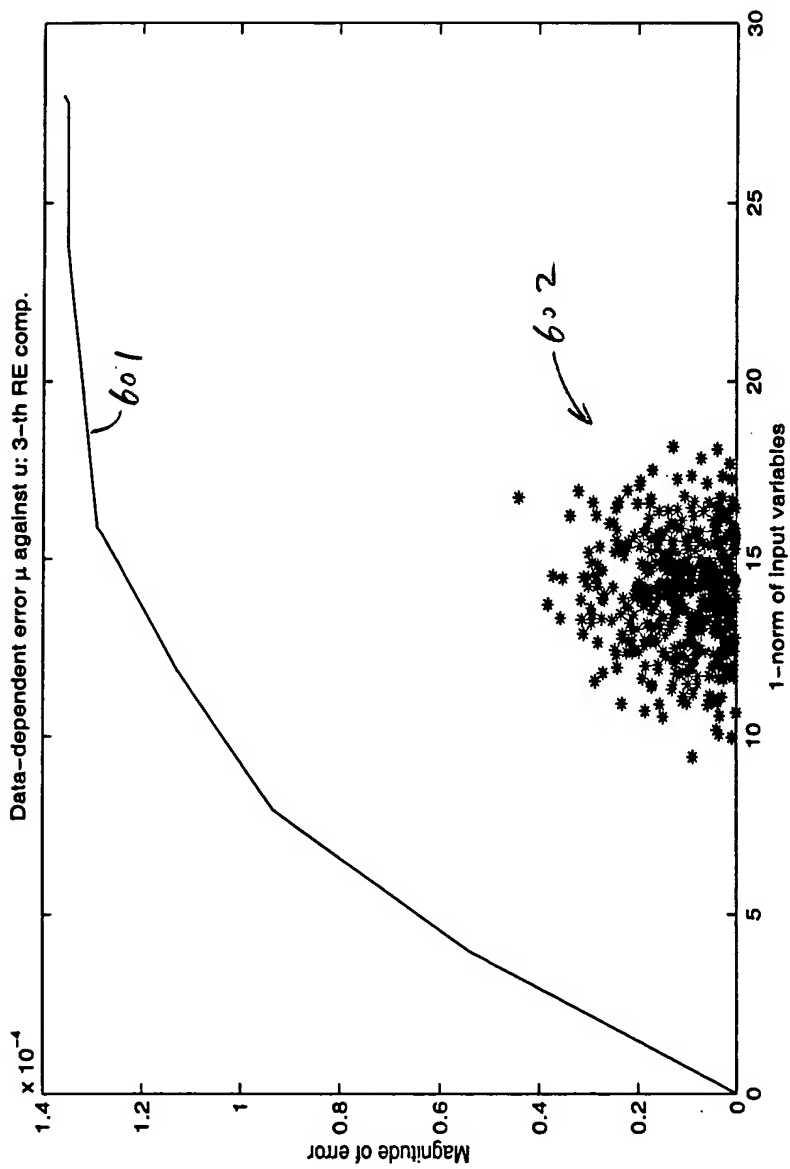


Fig. 6

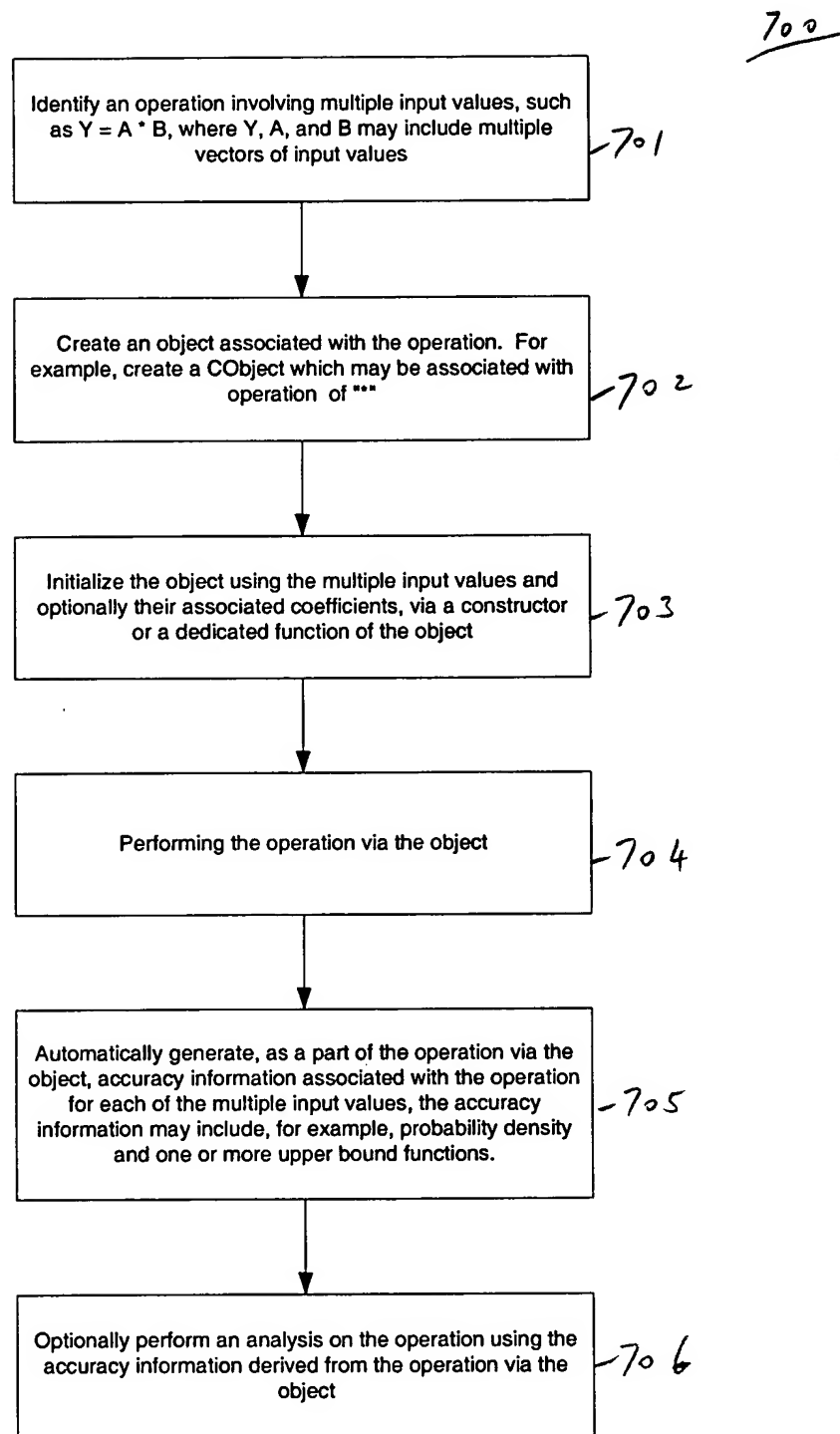
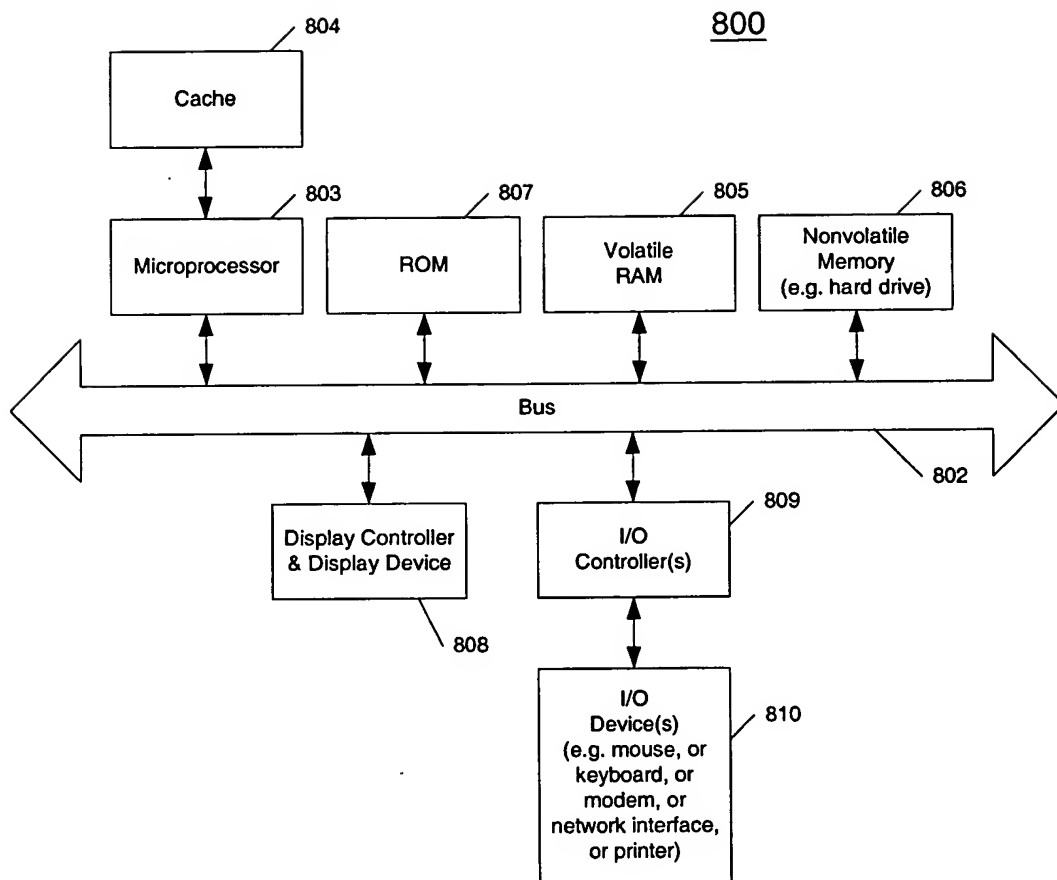


Fig. 7



**Fig. 8**